Prozesskalibrierung als fehlendes Glied zwischen realer Produktion und digitalem Zwilling
Process calibration – the missing link between an RTM-production line and its digital twin

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Automated RTM production in aerospace

…*why is it that difficult compared to automotive?*

automated production *must* run 24/7

- High invest cost for both automation as well as RTM-tools
- Cost only devided by number of parts

robust process needed

- to avoid 100% inspection of each individual part
- rework is not an option

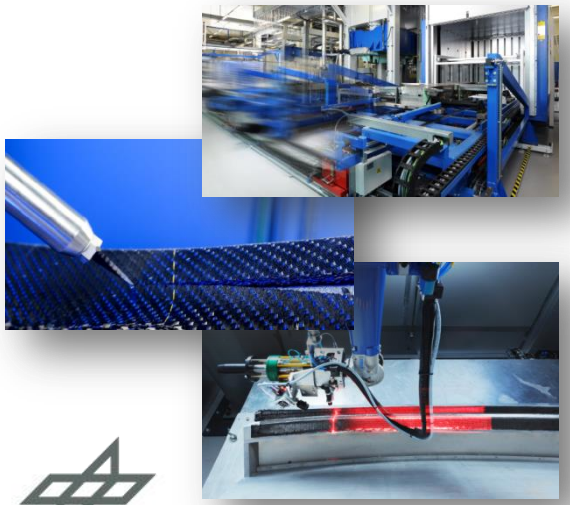
shipset-wise production of multiple parts („lotsize 1“)

- many different tools needed → more invest!
- flexibility makes process more complex → less robust!

Researchplatform „EVo“

… *technology* ***and scenario*** *demonstrator*

<u>key features</u>:
- net shape preforming
- isothermal injection
- automated mould exchange
- inline-QA
- automated mould preparation (in progress)



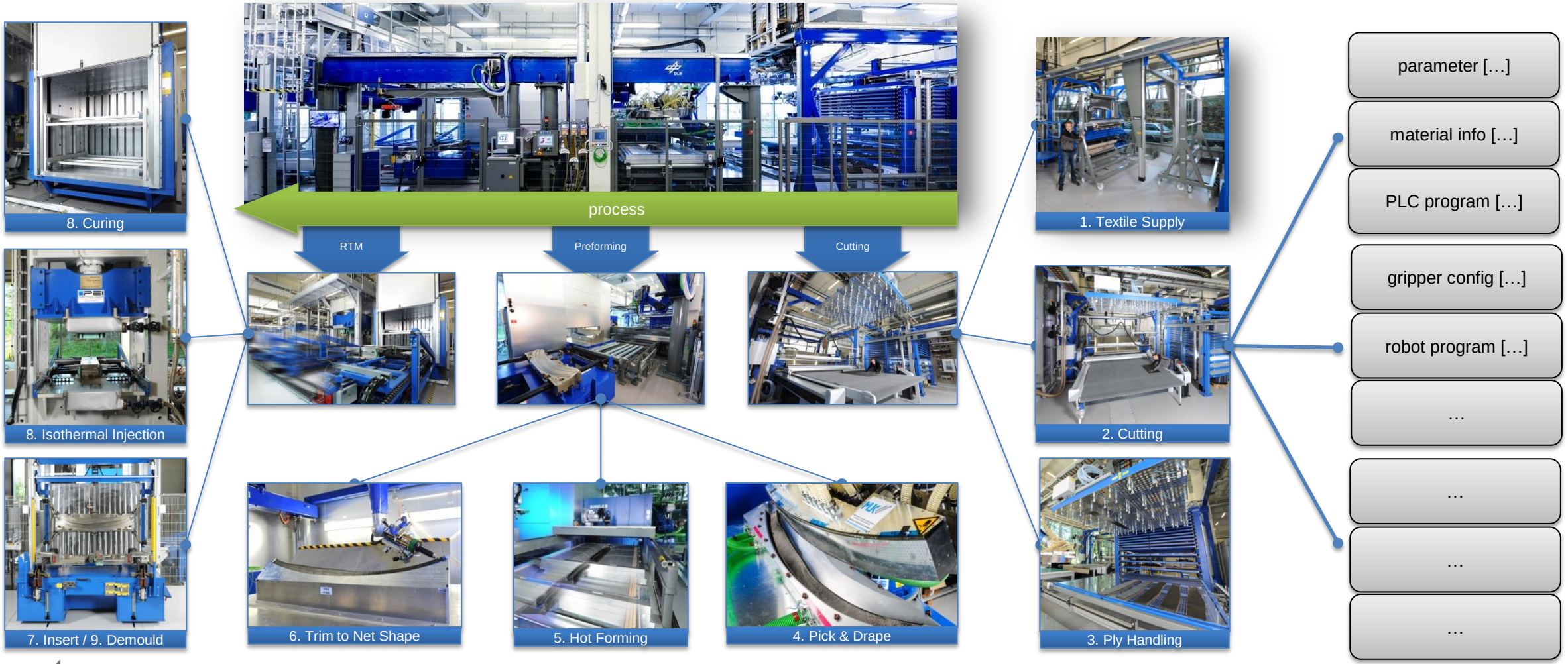
Automated Preforming & RTM production line

Target:
predictable *process for* ***lotsize 1*** *production*

<u>part portfolio:</u>
- fuselage frames
- ribs for empenage
- ribs for wing (in progress)
- Sandwich parts (in progress)

Researchplatform „EVo“

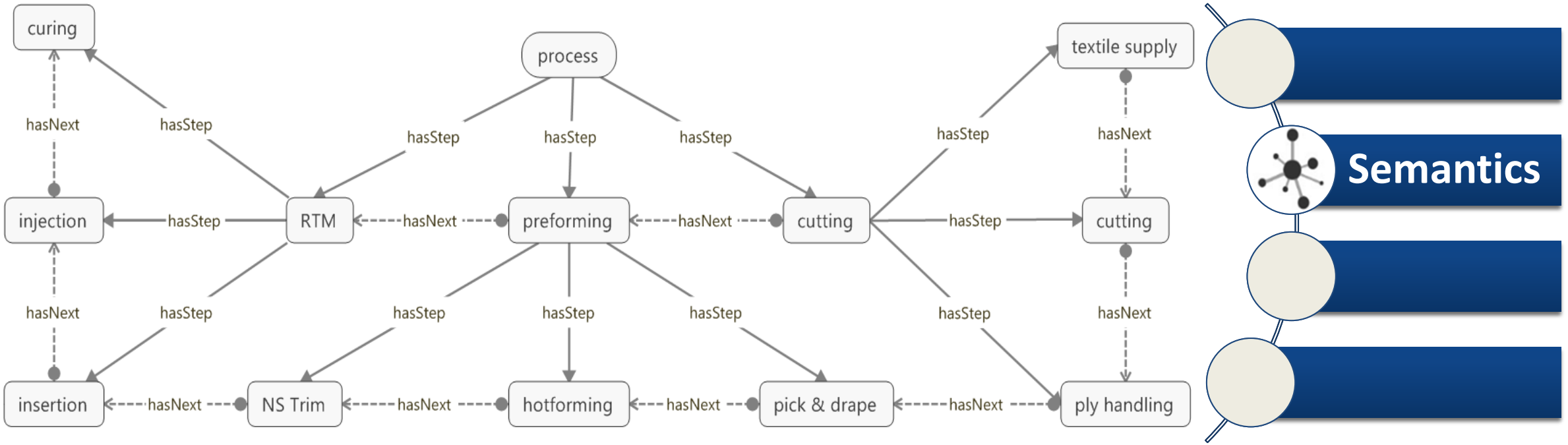
… a chain of subprocesses with a tail of data



Crosslinking

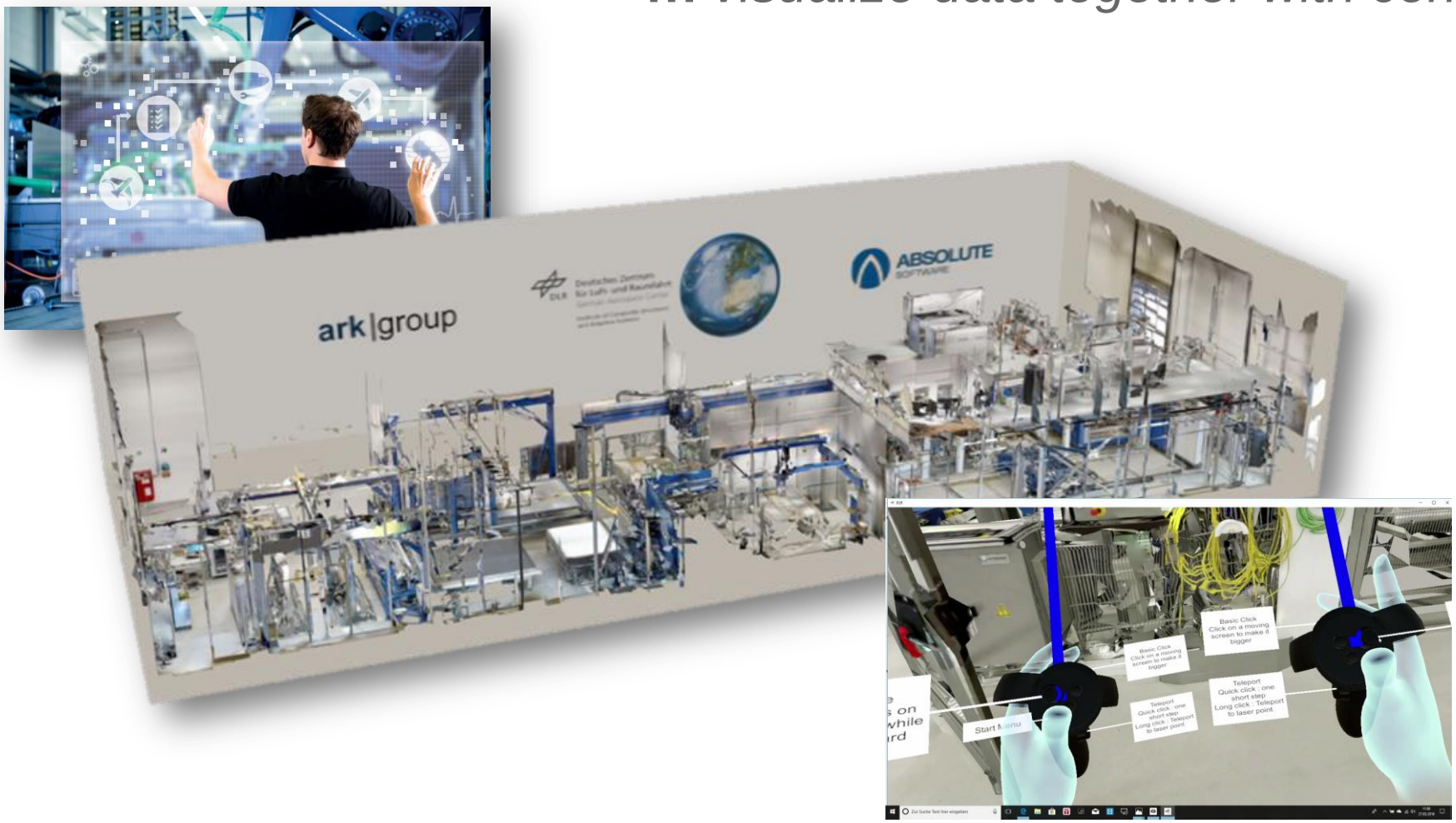
… the machine‘s mindmap for process-information

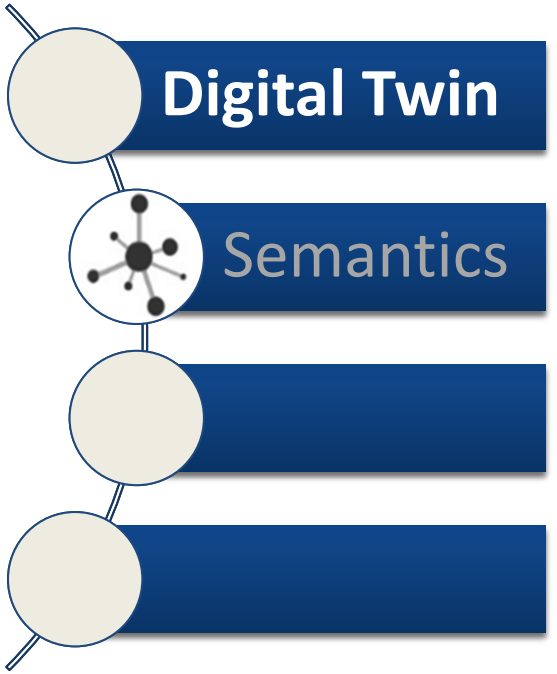
„Four Layer Architechture“



Digital Twin

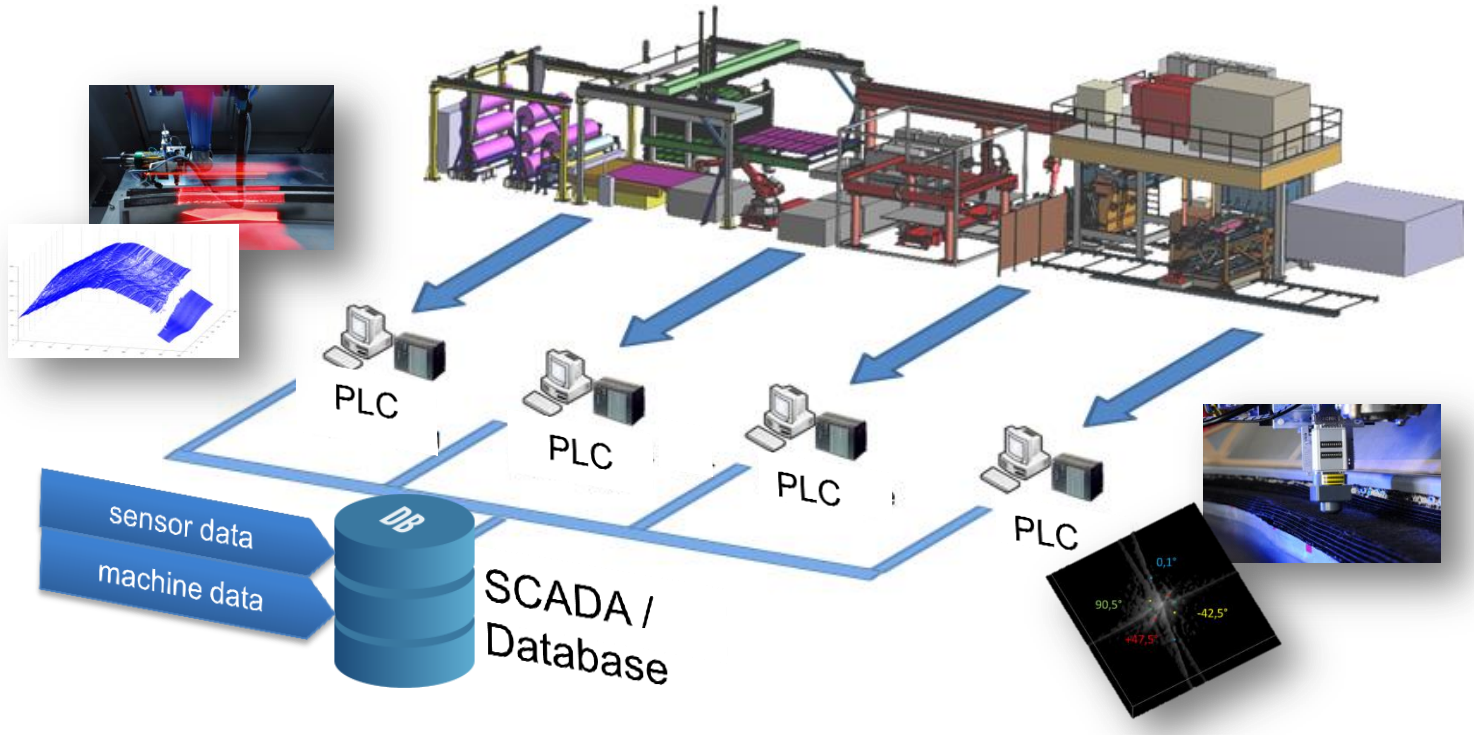
... visualize data together with context

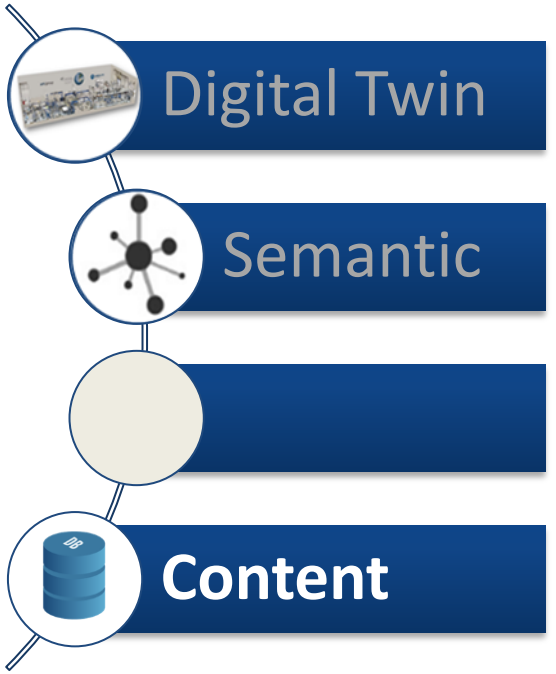




Data acquisition

… of machine parameters and QA sensors





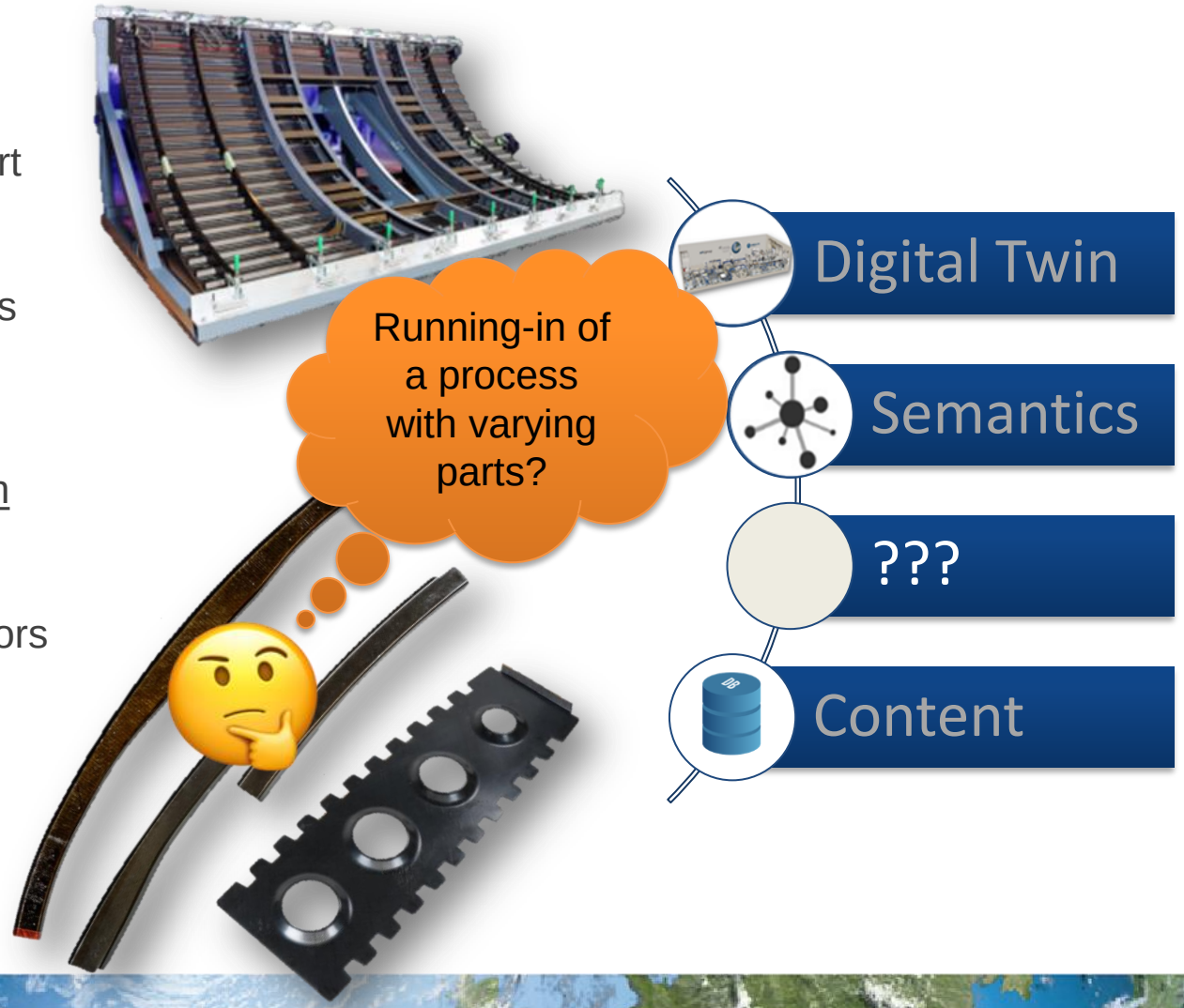
Individual Process regulation vs. Robust high volume production

<u>Individual production of large part:</u>

- Apply sensors on part
- Akquire Data
- (Simulate)
- **Regulate** parameters

<u>Serial production of high volume parts</u>

- Use machine‘s sensors
- **Running-in**
- Acquire Data
- Determine process-window



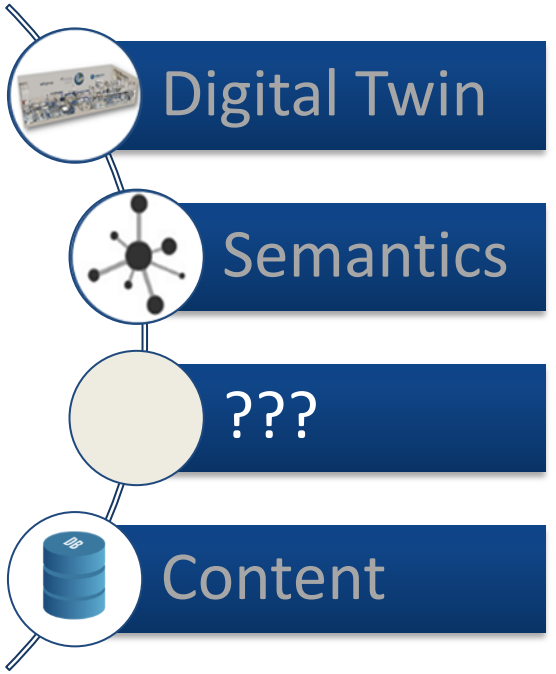
the missing link…

properties
- geometry
- compaction
- cure

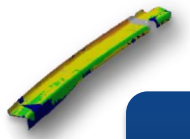
context
- process step
- dependency
- interaction

???

machine data
- acceleration
- pressure
- temperature

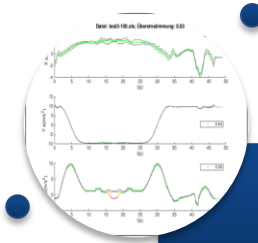


the missing link…



properties

context



calibration

machine data

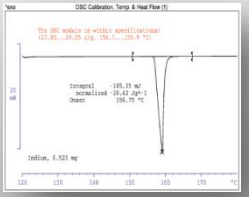
relate machine parameter to result on product

Examples:

- Balance with calibration weight
- DSC with Indium standard
- Tensile Test machine with reference specimen

5,0001g
=
5,0001g

source: Sartorius



Melting point
IN =
156,6°C

source: Mettler Toledo

Reference
specimen
=
Reference
value

source: Zwick

Calibration

… why do we need it?

example process: **hotforming**

- estimation:
  - flat surface

  →homogenious temperature and pressure destribution

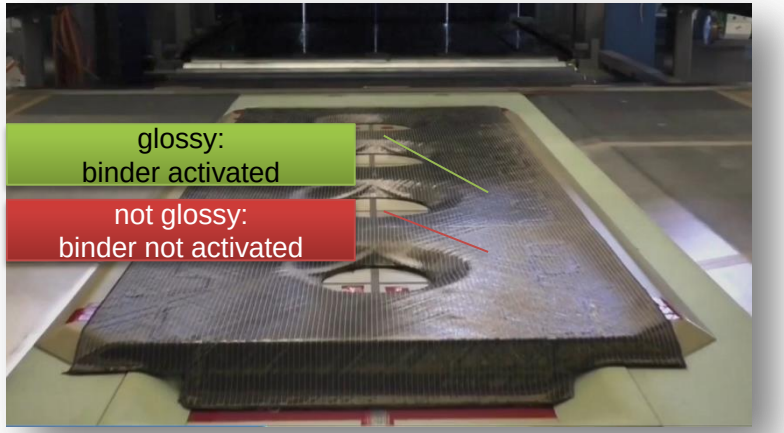
- reality:
  - stretches membrane over contoured surface

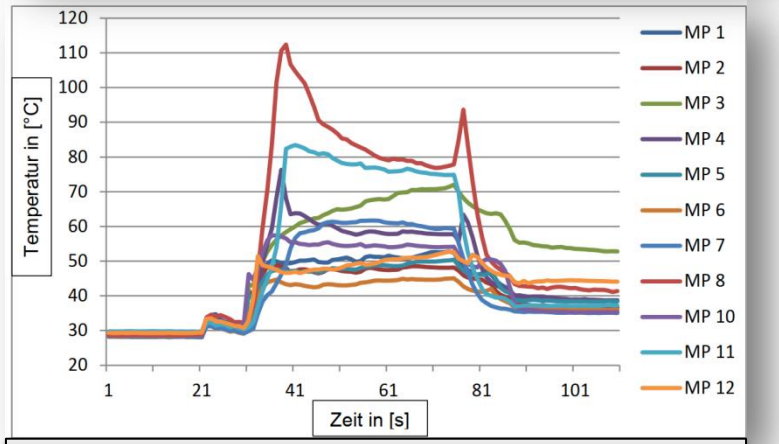
  → membrane thickness varies locally

  → membrane‘s elasticity works agains pressure

  → result:

  inhomogenious binder activation **depending on geometry**





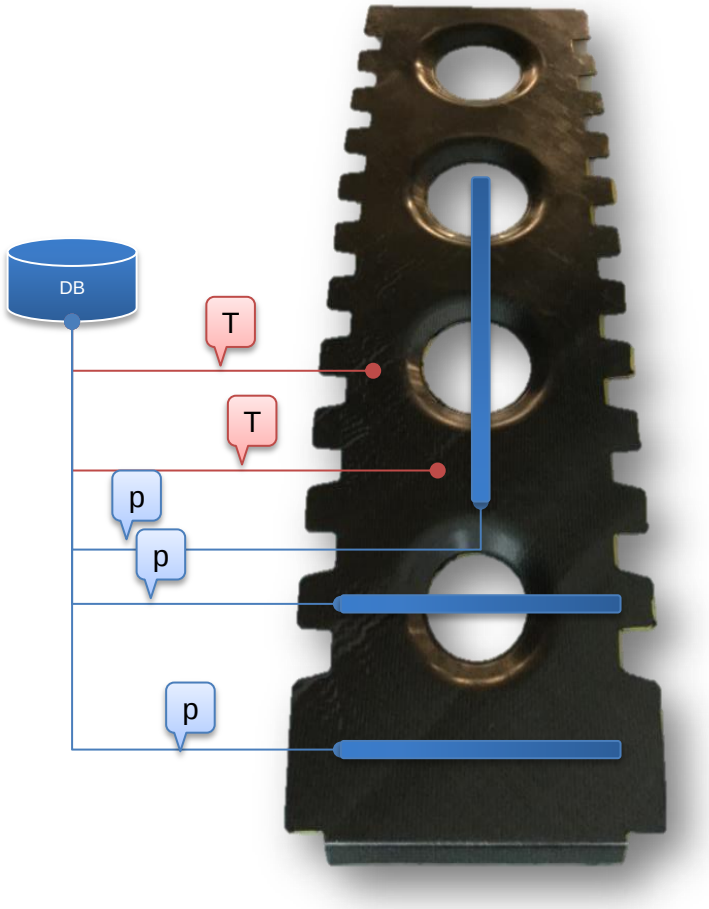
Inhomogenious temperature destribution over time

Calibration

… how can we do it?

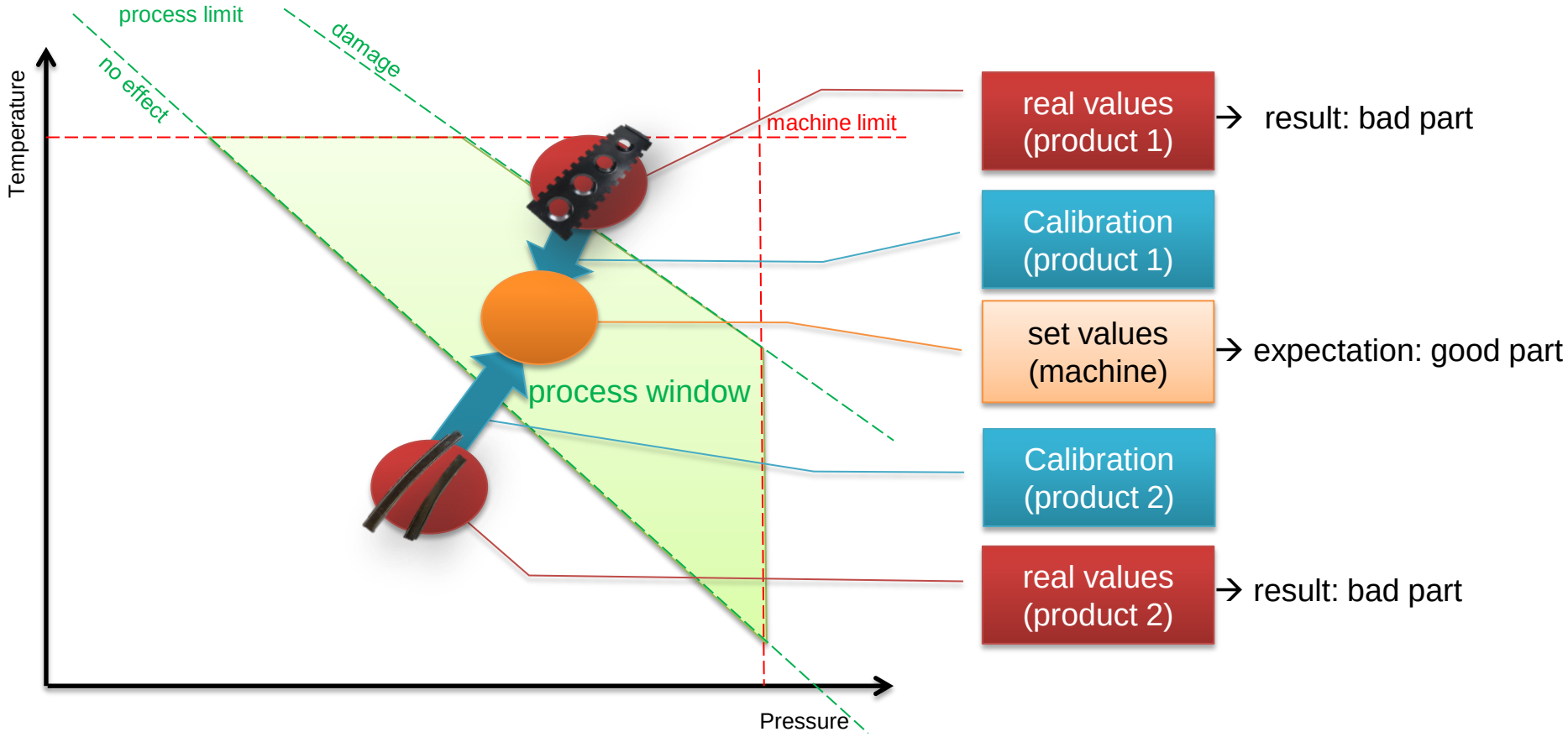
approach: **sensorized calibration part**

- separate part with integrated sensors
  - *not* the application of sensors to the product in production
- sensors will measure process parameters from the product‘s point of view
- results lead to calibration factor as link between *machine parameter* and product related *process parameter*



Variation of parts means variation of parameters

… but should not mean variation of quality



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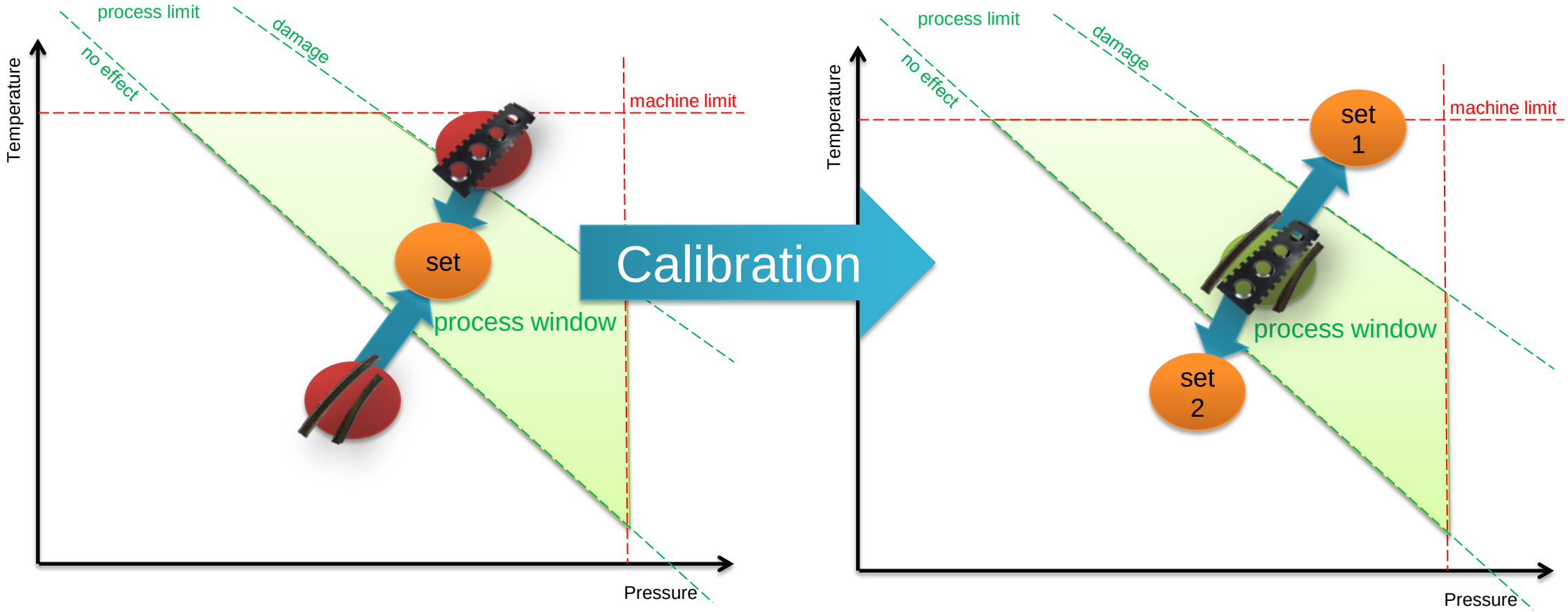


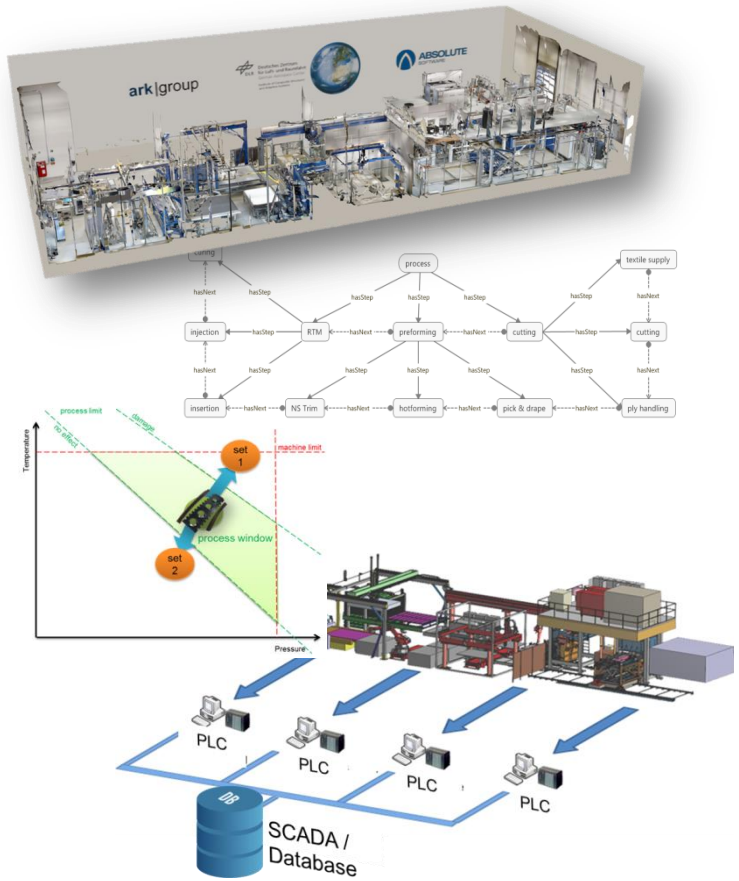
Vision Future Factory for RTM Parts:

… flexible production at constant quality

Automated Preforming & RTM production line

Target:
***predictable** process for **lotsize 1** production*

- Digital Twin
- Semantics
- Calibration
- Content




Thanks
for your
Attention!